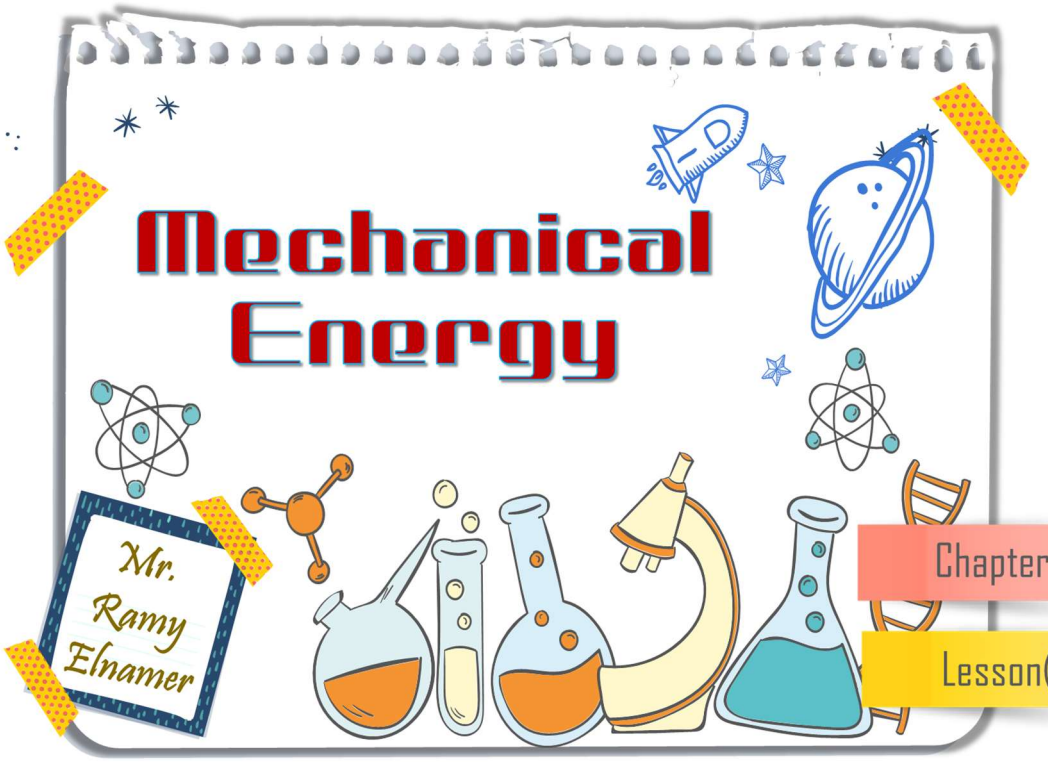


Energy: it's the ability to do work

Work is the seen form of Energy

The measuring unit of energy is same unit of work

$\left(\text{Joule} \equiv ML^2T^{-2}\right)$

Types of Mechanical Energy

Kinetic Energy
Energy of moving body

Potential Energy
Energy of static body

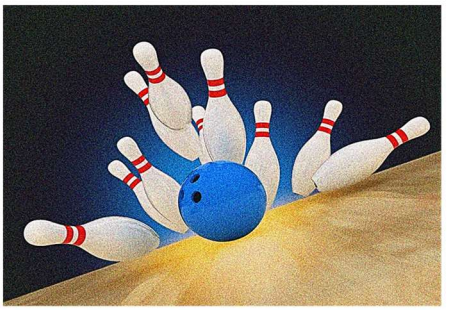
Kinetic Energy

Kinetic Energy: It is the work done during the object's motion

The kinetic Energy depends on ....

1. the mass of the body
2. the velocity of the body

$$KE = \frac{1}{2}mv^2$$



Other form of law

$$P = mv$$

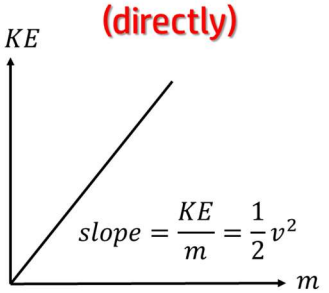
$$KE = \frac{1}{2}Pv \quad \text{or} \quad KE = \frac{P^2}{2m}$$

Kinetic energy is scalar quantity, why?
As it its product of the mass (scalar) and the square of velocity (scalar)

Factors affecting on the "Kinetic Energy"

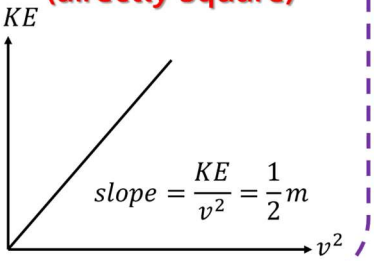
"While other factors are constant"

The mass of the moving body (directly)



$$KE = \frac{1}{2}mv^2$$

The speed of the moving body (directly square)



What is happening to the kinetic energy , if the velocity increases 4 times?

➢ Kinetic energy will increase 16 times $(\uparrow KE \propto \uparrow v^2)$

If the momentum of running boy is $300\ kg.m/s$, who is running with speed $5m/s$. find the kinetic energy of the body (use two different methods)

$$P = 300\ kgm/s$$
$$v = 5\ m/s$$
$$KE = ??\ \text{J}$$

1ST METHOD

$$P = mv$$
$$300 = m \times 5$$
$$m = 60\ kg$$
$$KE = \frac{1}{2}mv^2$$
$$KE = \frac{1}{2} \times 60 \times 5^2 = 750\ \text{J}$$

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}\ mv\ v$$

Where $P = mv$

$$\boldsymbol{KE = \frac{1}{2}Pv}$$

$$\boldsymbol{KE = \frac{P^2}{2m}}$$

2ND METHOD

$$KE = \frac{1}{2}Pv$$
$$KE = \frac{1}{2} \times 300 \times 5 = 750\ \text{J}$$

Two bodies have the same mass, but their speed is $v_2 = 2v_1$.
so, the Kinetic energy of the 1st body equals ..... the 2nd body

$$\boldsymbol{KE = \frac{1}{2}mv^2}$$

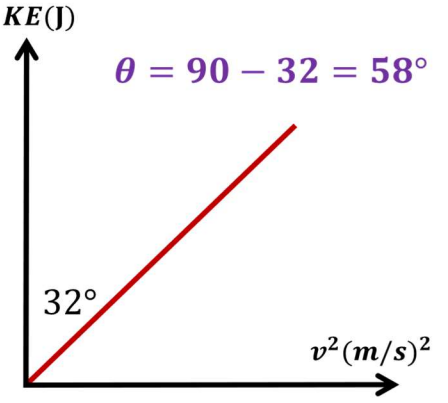
$KE \propto m$ & $KE \propto v^2$

$$\frac{KE_1}{KE_2} = \frac{m_1 \times v_1^2}{m_2 \times v_2^2}$$
$$\frac{KE_1}{KE_2} = \frac{v_1^2}{v_2^2}$$
$$\frac{KE_1}{KE_2} = \frac{(1)^2}{(2)^2} = \frac{1}{4}$$

$$m_1 = m_2$$
$$v_1 = 1\ v$$
$$v_2 = 2\ v$$
$$\frac{KE_1}{KE_2} = ??$$

The Kinetic energy of the 1st body equals quarter the 2nd body

From the opposite graph calculate the mass of the moving object and then find its speed when the $KE = 95$ J



$m = ??$
$v = ??$
$KE = 95$ J

$$slope = \boxed{\tan(\theta)}$$

$$slope = \frac{KE}{v^2} = \boxed{\frac{1}{2}m}$$

$$\tan(\theta) = \frac{1}{2}m$$

$$\tan(58) = \frac{1}{2}m$$

$$m = 3.2\ kg$$

$$KE = \frac{1}{2}mv^2$$

$$95 = \frac{1}{2} \times 3.2 \times v^2$$

$$v = 7.7\ m/s$$

CHANGE OF KINETIC ENERGY
"Work done during the motion"
$(W = \Delta KE)$

$$\Delta KE = KE_f - KE_i$$

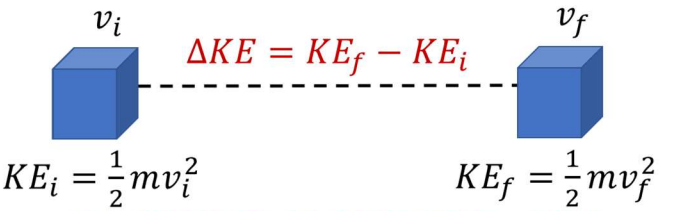
Where

$$KE_f = \frac{1}{2}mv_f^2 \quad \& \quad KE_i = \frac{1}{2}mv_i^2$$

$$\Delta KE = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$\Delta KE = \frac{1}{2}m\left(v_f^2 - v_i^2\right)$$

$$\boldsymbol{W = \Delta KE = \frac{1}{2}m\left(v_f^2 - v_i^2\right)}$$



Change of Kinetic Energy

KE: INCREASES
speed increases & work done $(+ve)$

KE: DECREASES
speed decreases & work done $(-ve)$

KE: DOESN'T CHANGE
Uniform speed & work done $(zero)$

~~$\Delta KE = \frac{1}{2}m\Delta v^2$~~

Car of mass $1200\ kg$ is moving on horizontal road, calculate the work done by the car engine to increase the car speed from $5 m/s$ to $10\ m/s$

The change of the car's velocity (ΔKE) is due to the work done (W) on the car

$$\boldsymbol{W = \Delta KE}$$

$$\boldsymbol{W = \Delta KE = \frac{1}{2}m\left(v_f^2 - v_i^2\right)}$$

$$W = \frac{1}{2} \times 1200 \times (10^2 - 5^2)$$

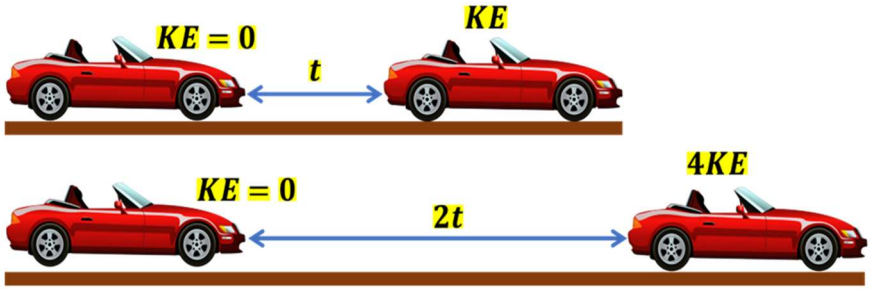
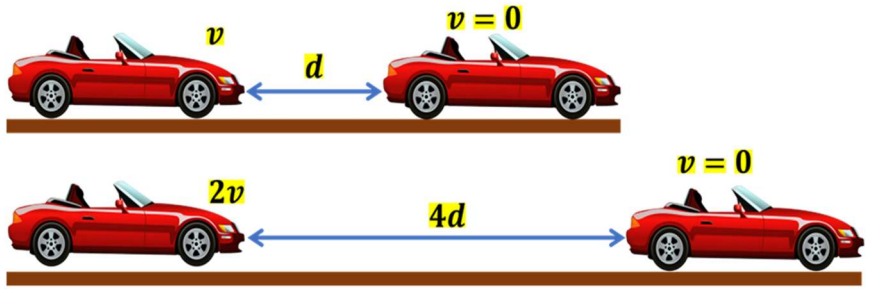
$$W = 45 \times 10^3\ \text{J}$$

$m = 1200\ kg$

$W = ??\ \text{J}$

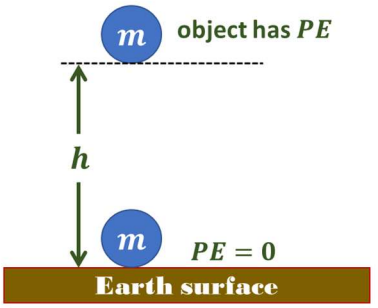
$v_i = 5\ m/s$

$v_f = 10\ m/s$

Relation between Kinetic energy and Time	Relation between Velocity and Distance
$v = at \quad \Rightarrow \quad v^2 = a^2t^2$ $KE = \frac{1}{2}mv^2 = \frac{1}{2}m \times (a^2t^2)$ $\boldsymbol{KE \propto t^2}$	$KE = W$ $\frac{1}{2}mv^2 = F.d$ $\boldsymbol{v^2 \propto d}$
	
Life Application If the time of motion increase to double, the kinetic energy increases to 4 times	**Life Application** If the velocity of the car increases to double , the stopping distance increases to 4 times

Potential Energy

Potential Energy: It is the stored Energy in a body due to the work done on it



What is the Potential Energy of the body on the Earth surface?

➢ $\because h = 0 \ \therefore PE = zero$

When work (W) is done on a body to lift it up to height (h)

$$W = Fd$$

The displacement (d) which the body moved is the height (h)

$$W = Fh$$

The force (F) of lifting body is the weight of it $F_g = mg$

$$W = mgh$$

The work done on the body is stored on it as Potential Energy

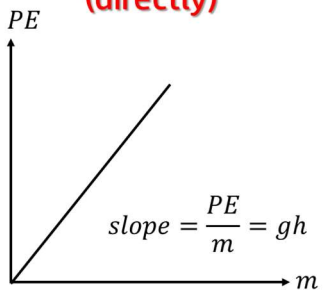
$$PE = mgh = F_g h$$

Factors affecting on the "Potential Energy"

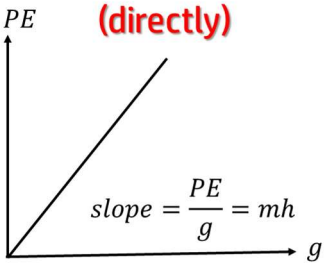
"While other factors are constant"

$$PE = mgh$$

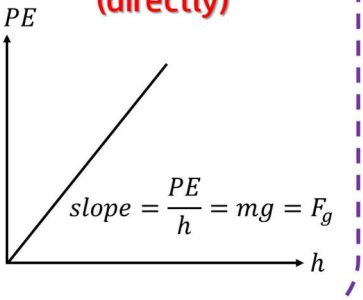
The mass of the object (directly)



The gravity acceleration (directly)



The height of the body (directly)



Calculates the work done to lift a body (PE) of mass $50kg$ to height of $2.2m$ above the Earth surface ($g = 10\ m/s^2$)
, Then find potential energy of the same body at Mars planet at the same height if you know that the weight of that body at mars $185\ N$

ON EARTH

$$PE = mgh$$
$$PE = 50 \times 10 \times 2.2$$
$$PE = 1100\ \text{J}$$

$PE = ??\ \text{J}$
$m = 50\ kg$
$h = 2.2\ m$
$g = 10\ m/s^2$
$PE_{(M)} = ??\ \text{J}$
$(F_g)_M = 185\ N$

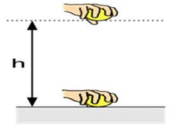
ON MARS

$$PE_{(M)} = mg_M h = (F_g)_M \times h$$
$$PE_{(M)} = 185 \times 2.2 = 407\ \text{J}$$

If you know that the potential Energy of a boy at the height of $5m$ is 4×10^4 J what is the boy's potential energy above the 3rd floor if you know that every floor is $4\ m$ height

$$PE = mgh \quad \Rightarrow \quad PE = \cancel{m}\ \cancel{g}\ h$$
$$PE \propto h$$
$$\frac{PE_1}{PE_2} = \frac{h_1}{h_2}$$
$$\frac{4 \times 10^4}{PE_2} = \frac{5}{12}$$
$$PE_2 = 9.6 \times 10^4\ \text{J}$$

$h_1 = 5m$
$PE_1 = 4 \times 10^4\ \text{J}$
$PE_2 = ??$
$h_2 = 3 \times 4 = 12\ m$
$m_1 = m_2$
$g_1 = g_2$

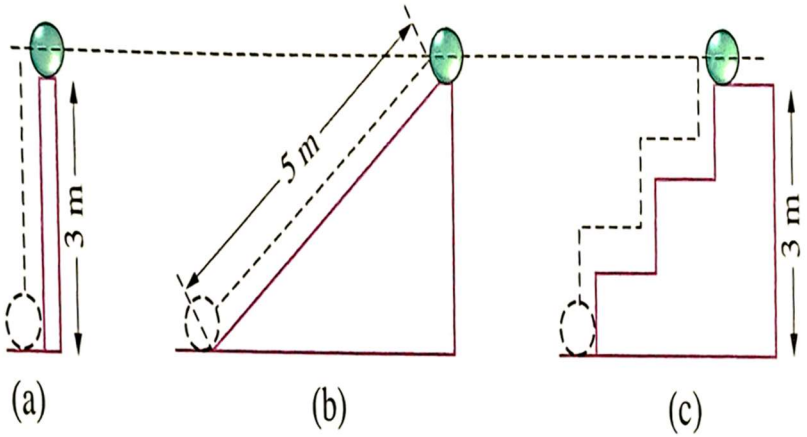
Examples of potential (Stored) Energy			
Gravitational potential energy Due to the height of the object above the earth surface		**Elastic potential energy of rubber** Due to the stretching of the rubber	
Chemical potential energy Due to the electric energy stored into the battery		**Elastic potential energy of spring** Due to the stretching of the spring	

Which of the following cases the work done on the ball (PE) is greatest if the ball reaches to the same height

Answer: all the same

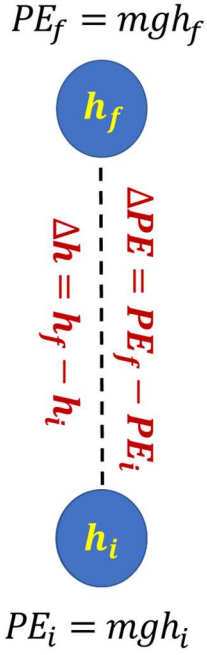
Explanation

The work done to move the ball are the same because the same ball reaches to the same height $(PE = mgh)$



- **At the previous example. When the potential energy is negative** $(PE = -ve)$
- If the ball goes below the earth surface ,as its height will be negative value

CHANGE OF POTENTIAL ENERGY



$$\Delta PE = PE_f - PE_i$$

Where

$$PE_f = mgh_f$$

$$PE_i = mgh_i$$

$$\Delta PE = mgh_f - mgh_i$$

$$\Delta PE = mg\left(h_f - h_i\right)$$

$$\boldsymbol{\Delta PE = mg\Delta h}$$

Change of Potential Energy

PE: INCREASES
Going up, height increases

PE: DECREASES
Going down, height decreases

PE: DOESN'T CHANGE
Height doesn't change
Move horizontally

$$\boldsymbol{W = \Delta PE = mg\Delta h}$$

A ball of mass $0.7\ kg$ is projected upward from height $2.5m$ to reach $8.3\ m$. What is the difference in potential energy because of reaching that height and then find the difference in the ball's potential energy moved the same distance horizontally knowing that $g = 10\ m/s^2$

GOING UP

$$\boldsymbol{\Delta PE = mg\Delta h}$$

$$\boldsymbol{\Delta PE = mg\left(h_f - h_i\right)}$$

$$\Delta PE = 0.7 \times 10 \times (8.3 - 2.5) = 40.6\,\text{J}$$

MOVE HORIZONTALLY

The ball's potential difference if it moved horizontally $\Delta PE = \ zero$,Because $\Delta h = zero$

$m = 0.7\ kg$
$h_i = 2.5\ m$
$h_f = 8.3\ m$
$\Delta PE = ??\,\text{J}$
$g = 10\ m/s^2$

	Kinetic Energy (motion)	Potential Energy (Rest)
Definition	It is the work done during the object's motion	It is the stored Energy in a body due to the work done on it
laws	$KE = \frac{1}{2}mv^2$ Other form of law $KE = \frac{1}{2}Pv = \frac{P^2}{2m}$ Difference law $W = \Delta KE = \frac{1}{2}m\left(v_f^2 - v_i^2\right)$	$PE = mgh$ Other form of law $PE = F_g h$ Difference law $W = \Delta PE = mg(h_f - h_i)$
When to equals (0)	The object at rest $v = 0$	At Earth surface $h = 0$
Type	Scalar quantity	Scalar quantity
unit	Joule (J)	Joule (J)